



# *Assessing the Potential Health Impact of the 1991 Gulf War on Saudi Arabian National Guard Soldiers in Health Research: A Formula for Success*

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# Assessing the potential health impact of the 1991 Gulf War on Saudi Arabian National Guard Soldiers

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**Background** There has been considerable publicity that the 1991 Gulf War may have caused a wide array of health problems in military personnel. Although post-war health outcomes have been studied in US, British, Canadian, Danish, and other deployed troops, this issue has not been previously evaluated in coalition forces native to the Gulf region.

**Methods** A collaborative team of US and Saudi health researchers was assembled, data sources evaluated, and hospitalizations among Saudi Arabian National Guard (SANG) soldiers between 1991 and 1999 analysed. Multivariate modelling was used to evaluate differences between 8342 soldiers exposed to combat at Al Khafji and a comparison group of 7270 soldiers in the Riyadh area.

**Results** Among 15 612 SANG soldiers, we identified 148 with at least one hospitalization over the 9 years following the war. The adjusted rate of hospitalization was higher in the combat-exposed group (risk ratio (RR) = 1.80, 95% confidence interval (CI) 1.25–2.59). No unusual patterns of diagnoses were found and, because the overall number of hospitalizations was low, the absolute difference in risk was found to be very small.

**Conclusions** This is the first reported epidemiological investigation of post-war hospitalizations among coalition forces native to the Gulf region that participated in the 1991 Gulf War. A very small increase in hospitalizations was identified in SANG soldiers exposed to combat at Al Khafji. However, because of data limitations, the clinical relevance of this finding should be interpreted with caution. Future collaborative studies to better understand the health effects of deployment should be encouraged.

**Keywords** Saudi Arabia, Persian Gulf syndrome, Gulf War syndrome, morbidity, hospitalization, military personnel, military medicine, military deployment, veterans, health, occupational exposure, environmental exposure

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In response to the Iraqi invasion of Kuwait, the United Nations coalition forces began a military build-up in the Gulf region in August 1990 and on January 16, 1991, launched air strikes against Iraqi targets. With air supremacy established, ground operations commenced on February 24, 1991, and continued for just 100 hours.<sup>1</sup> A substantial drawdown was initiated once combat operations ceased, and by the end of June 1991, the vast majority of coalition troops had returned to their homes. This is the context in which concern for a wide variety of post-deployment health issues emerged.

Shortly after the 1991 Gulf War ended, some US veterans began reporting symptoms and illnesses that they attributed to their war-related experiences.<sup>2–6</sup> Coalition partners from the UK, Canada, Australia, and Denmark also reported multi-symptom

conditions that veterans attributed to their participation in the Gulf War conflict.<sup>7–22</sup> Prompted by veteran and general public concern, multiple studies were initiated to investigate the potential health impact of the Gulf War. What has emerged after more than a decade of research is that certain symptoms, primarily fatigue, cognition problems, and musculoskeletal complaints, are reported more frequently among Gulf War veterans than non-deployed veterans of the same era.<sup>23–27</sup> However, these symptoms or symptom-based conditions are also common in the general population and have been previously noted among veterans of other military deployments.<sup>26,28–30</sup> A number of aetiological possibilities have been examined,<sup>31</sup> including occupational and environmental exposures,<sup>32–39</sup> infectious agents,<sup>40</sup> immunizations,<sup>41</sup> and psychological stressors.<sup>42–44</sup> Despite exhaustive epidemiological study, specific Gulf War exposures have not been causally associated with self-reported illnesses or conditions, and the aetiology of these subjective health outcomes remains unclear.<sup>3,26,30,32,45–51</sup>

To our knowledge, a systematic evaluation of military personnel native to the Gulf region has not been conducted previously. Discussions between US and Saudi Arabian officials led to an opportunity to assess the potential health impact of the 1991 Gulf War on Saudi Arabian National Guard (SANG) soldiers. SANG soldiers played a major role in a battle at Al Khafji, a town located along the border between the Kingdom of Saudi Arabia and Kuwait. The soldiers who fought in the Battle of Al Khafji represent a unique study group within SANG because their war-related experiences may have been similar to those of other coalition forces. If war exposures result in post-war morbidity, then SANG soldiers who served at Al Khafji during January 1991 might be expected to have different health outcomes compared with SANG soldiers who served at sites distant from the front lines of combat in Saudi Arabia. A 10-member team of Saudi and US investigators was assembled to conduct a health study of SANG members to add to the body of knowledge on the complex health issues surrounding the 1991 Gulf War. In this article, we report the epidemiological findings from our investigation.

## Preliminary studies

In late 1999, our collaborative research team met in Saudi Arabia at King Abdul Aziz Medical City (KAMC), formerly known as King Fahad National Guard Hospital. KAMC is a large, 560-bed, tertiary care medical centre in Riyadh, established in 1981 to provide primary care and advanced diagnostic, therapeutic, and other referral services for SANG soldiers and their family members. Two Saudi researchers from KAMC and eight from the United States, representing the Uniformed Services University of the Health Sciences (USUHS), the Centres for Disease Control and Prevention (CDC), and the Department of Defense Centre for Deployment Health Research at the Naval Health Research Centre (NHRC), comprised our research team. Our initial tasks involved characterizing available health data and evaluating their suitability for inclusion in an analysable dataset. Data on hospitalizations, ambulatory care, prescription medication use, cancer registry, and mortality at KAMC were evaluated. We subsequently identified SANG soldiers stationed at Riyadh as a comparison

group for soldiers who were at Al Khafji, where open hostilities took place. After evaluating each of the available data sources, we were only able to use automated hospitalization records maintained at KAMC as a measurable post-war health outcome for our study.

## Methods

### Study population and data sources

We identified 15 612 SANG soldiers who were on active duty during the 1991 Gulf War, 8342 located at Al Khafji and 7270 located in the Riyadh area during the period January 1–February 1, 1991. Demographic and deployment data for SANG personnel were provided by the Office of Personnel at SANG Headquarters. These data included a unique linking variable, date of birth, rank (enlisted or officer), military status (active, resigned/discharged, detained/transferred), first date of active service, and date of separation from military service. Automated health records maintained at KAMC were linked to deployment and demographic data for the period January 1, 1989–December 31, 1999, to create an analytical dataset. Health information for each SANG member included medical record number, unique identifiers, demographic information (sex, estimated age, minimum age, and eligibility code), and medical information (up to eight hospitalization discharge diagnoses, dates of care, up to five procedure codes, and up to two special care unit codes per hospitalization).

### Statistical analyses

We examined hospitalizations resulting from all causes, as well as diagnoses in 14 major categories of the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM)<sup>52</sup> from January 1, 1991 to December 31, 1999.

To compare the hospitalization experience of the two groups of SANG soldiers, while accounting for attrition, including resignation or discharge from military service, we used Cox proportional hazard regression analysis. Only the first hospitalization for each of the targeted outcomes was included for each SANG soldier in our study population, as in the method used by Gray *et al.*<sup>33</sup> Time to event was calculated from January 1, 1991, until hospitalization, separation from SANG service, or December 31, 1999, whichever occurred first. Using SAS<sup>®</sup> version 9.0 (SAS Institute, Cary, North Carolina, USA),<sup>53</sup> we calculated crude and adjusted risk ratios (RRs) and 95% confidence intervals (CIs) by location (Al Khafji vs Riyadh) and other demographic and military service variables for the 15 612 SANG soldiers. Finally, we compared the probability of all-cause hospitalization between the Al Khafji and Riyadh soldiers as a function of time.

Preliminary analyses using Cox regression included estimates of crude RRs for location during the Gulf War (Al Khafji vs Riyadh), age (quartiles), length of service (quartiles), military rank (officer vs enlisted), and active-duty status (active, resigned/discharged, detained/transferred), and at least one hospitalization for any cause. Regression diagnostics revealed the absence of collinearity, but the likely presence of significant interaction between age and length of service. A manual, backward stepwise regression technique was used to construct the final model, which included age and length of service as continuous variables, age by length of service interaction term, and location.

Institutional assurances and approvals were obtained from USUHS, CDC, NHRC, and KAMC. Unique identifiers were used for linking purposes only and subsequently deleted by data managers at KAMC.

## Results

Demographic and military service data were available for 8342 SANG soldiers stationed at Al Khafji and 7270 SANG soldiers stationed at Riyadh (Table 1). The age distribution in the two groups was comparable (mean age was 32.6 years for the Al Khafji group and 32.5 years for the Riyadh group). Similarly, there was very little difference noted in length of service between the two groups (mean length of service was 5.9 years for Al Khafji and 5.7 years for Riyadh). Although the Al Khafji group had a greater proportion of officers, the distribution across all rank categories was roughly comparable in the two groups (data not shown). Finally, the vast majority of SANG soldiers remained on active duty (91%) during our study period, even though a relatively greater proportion resigned or were discharged from service in the Riyadh group (13.4%) compared with the Al Khafji group (1.9%).

Table 2 displays crude RRs and the adjusted RR for all-cause post-war hospitalizations among SANG soldiers at KAMC from January 1, 1991–December 31, 1999. A total of 148 SANG soldiers were hospitalized one or more times over the 9-year study period (108 among Al Khafji soldiers vs 40 among Riyadh soldiers). Those soldiers serving in the Al Khafji area were more

likely to be hospitalized compared with those soldiers stationed in the Riyadh area (crude RR = 2.16, 95% CI 1.50–3.10). Length of service  $\geq 9$  years was a predictor for hospitalization (crude RR = 11.28, 95% CI 6.33–20.09) as was enlisted military rank (crude RR = 4.41, 95% CI 3.19–6.09). The adjusted relative risk for all-cause hospitalizations was 1.80 (95% CI 1.25–2.59).

Table 3 lists the adjusted RRs for post-war hospitalizations in the two study groups within 14 major ICD-9-CM diagnostic categories. A total of 285 diagnoses in the 14 categories were identified among the 148 individuals who were hospitalized. Although no single category was statistically significant, the relative risk of post-war hospitalization was increased in the Al Khafji group compared with the Riyadh group across all 14 major categories.

Figure 1 shows the frequency of hospitalizations by calendar year for each of the study groups between 1989 and 1999. The frequency of post-war hospitalizations among the soldiers stationed at Al Khafji is parallel but consistently higher than hospitalizations among those stationed at Riyadh.

Figure 2A and B illustrate the cumulative probability of all-cause post-war hospitalization at KAMC over the 9-year period of observation since January 1, 1991, comparing SANG soldiers stationed at Al Khafji with those at Riyadh. Although the probability of hospitalization gradually increases for both groups over time, the lines diverge, with the Al Khafji group having a small, but statistically significant, higher probability of hospitalization when compared with the Riyadh group. The difference in cumulative probability of hospitalization is 0.004415 at the end of 1999. The mean follow-up time for Al Khafji soldiers was 8.90 years and for Riyadh soldiers 8.21 years.

## Discussion

To our knowledge, this is the first study to examine the post-war hospitalization experience among coalition forces native to the Gulf region. While a number of large epidemiological studies have found an increase in self-reported illnesses in Gulf War veterans who were deployed to the Gulf from outside the region, similar findings among Saudi veterans have not been reported in the scientific literature. Although not systematically assessed, we were not aware of any Gulf-War-related health concerns voiced by SANG veterans or by health care providers during the conduct of our study. Because we were able to identify one group of SANG soldiers stationed in a combat zone and another stationed some distance from the fighting, we were able to design a study to compare possible post-war health outcomes in these two groups of soldiers using existing automated health data. After an initial inventory of possible data sources, we had to limit our study to hospitalization discharge diagnoses at KAMC.

Overall, it is remarkable that so few hospitalizations, 148 total, were identified during the 9-year study period (0.95% of our SANG population). By way of comparison, 19.4% of US Gulf War veterans were hospitalized at least once over a similar period of observation (August 1, 1991–July 31, 1999).<sup>36</sup> To the extent that we were able to ascertain hospitalizations at KAMC during the 9-year period of observation, we noted a consistent excess in the number of hospitalizations among the Al Khafji soldiers for all causes as well as for each of the 14 major

**Table 1** Demographic and military service characteristics of Saudi Arabian National Guard soldiers stationed at Riyadh and Al Khafji, January 1–February 1, 1991

Variable	Population <i>n</i> = 15 612	Riyadh <i>n</i> = 7270	Al Khafji <i>n</i> = 8342
	Number (%)	Number (%)	Number (%)
<b>Age (years)<sup>a</sup></b>			
18–29	3599 (23.1)	1910 (22.9)	1689 (23.2)
30–32	4044 (25.9)	2161 (25.9)	1883 (25.9)
33–35	4265 (27.3)	2285 (27.4)	1980 (27.3)
36–52	3704 (23.7)	1986 (23.8)	1718 (23.6)
<b>Length of service (years)<sup>a</sup></b>			
0–3	4433 (28.4)	2318 (27.8)	2115 (29.1)
4–5	3710 (23.8)	1998 (23.9)	1712 (23.6)
6–8	4364 (27.9)	2290 (27.5)	2074 (28.5)
$\geq 9$	3105 (19.9)	1736 (20.8)	1369 (18.8)
<b>Military rank<sup>b</sup></b>			
Officer	1971 (12.6)	502 (6.9)	1469 (17.6)
Enlisted	13 641 (87.4)	6768 (93.1)	6873 (82.4)
<b>Active-duty status<sup>b</sup></b>			
Active	14 250 (91.3)	6171 (84.9)	8079 (96.8)
Resigned/discharged	1134 (7.2)	976 (13.4)	158 (1.9)
Detained/transferred	228 (1.5)	123 (1.7)	105 (1.3)

<sup>a</sup> Age and length of service (grouping by quartile) were computed as of August 1, 1991.

<sup>b</sup> Military rank and active-duty status were ascertained as of 1991.

**Table 2** Crude RRs for all-cause post-war hospitalization among Saudi Arabian National Guard soldiers at KAMC, January 1–December 31, 1999

Variable	Number	Number (% hospitalized)	Crude RR	95% CI	Adjusted RR	95% CI
<b>Exposed to fighting</b>						
Riyadh <sup>a</sup>	7270	40 (0.55)	—	—	—	—
Al Khafji	8342	108 (1.29)	2.16	1.50–3.10	1.80	1.25–2.59
Total	15 612	148 (0.95)				
<b>Age (years)</b>						
18–29 <sup>a</sup>	3599	45 (1.25)	—	—	—	—
30–32	4044	24 (0.59)	0.48	0.29–0.78		
33–35	4265	19 (0.45)	0.36	0.21–0.61		
36–52	3704	60 (1.62)	1.31	0.89–1.92		
<b>Length of service (years)</b>						
0–3 <sup>a</sup>	4433	13 (0.29)	—	—	—	—
4–5	3710	14 (0.38)	1.28	0.60–2.73		
6–8	4364	20 (0.46)	1.56	0.78–3.14		
≥9	3105	101 (3.25)	11.28	6.33–20.09		
<b>Military rank</b>						
Officer <sup>a</sup>	1628	67 (4.12)	—	—	—	—
Enlisted	8811	81 (0.92)	4.41	3.19–6.09		
Missing	5173	0 (0.0)				
<b>Active-duty status</b>						
Active <sup>a</sup>	14 250	137 (0.96)	—	—	—	—
Resigned/discharged	1134	9 (0.79)	2.16	1.09–4.27		
Detained/transferred	228	2 (0.88)	0.95	0.24–3.85		

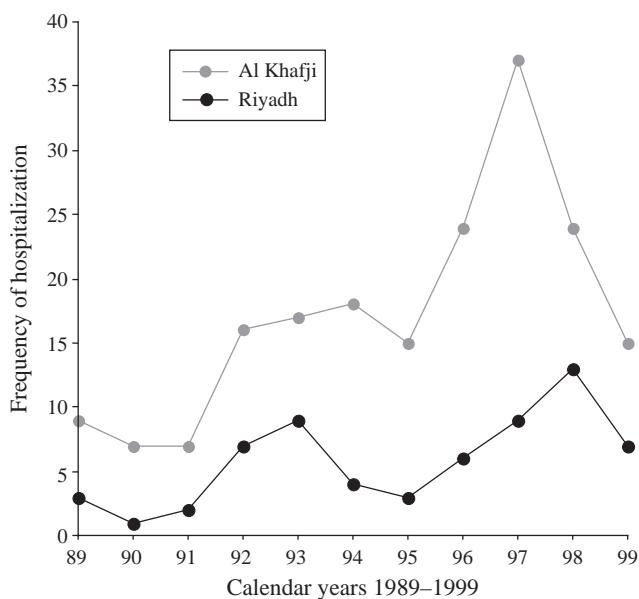
RR, risk ratio; CI, confidence interval.

Age and length of service grouped by quartile.

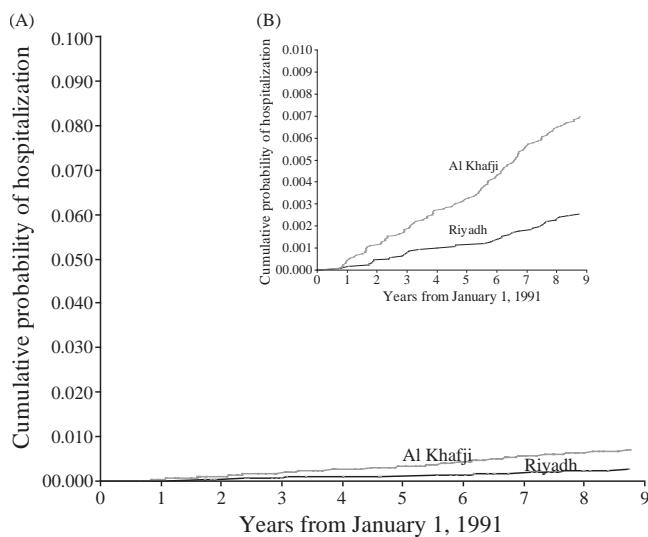
<sup>a</sup> Reference category.**Table 3** Adjusted RRs for the major diagnostic categories of post-war hospitalization at KAMC, January 1–December 31, 1999

ICD-9-CM Codes	Major diagnostic categories	Number (% hospitalized with diagnosis)			
		Al Khafji (n = 8342)	Riyadh (n = 7270)	Adjusted RR	95% CI
001–139	Infection and parasitic diseases	12 (0.14)	2 (0.03)	3.83	0.84–17.38
140–239	Neoplasms	8 (0.10)	1 (0.01)	5.22	0.65–42.09
240–279	Endocrine, nutritional, and metabolic diseases	16 (0.19)	6 (0.08)	1.50	0.58–3.90
280–289	Blood diseases	9 (0.11)	0 (0.00)	—	—
290–319	Mental disorders	4 (0.05)	0 (0.00)	—	—
320–389	Nervous system diseases	13 (0.16)	4 (0.06)	2.24	0.72–6.89
390–459	Circulatory system diseases	25 (0.30)	9 (0.12)	1.76	0.82–3.81
460–519	Respiratory system diseases	25 (0.30)	13 (0.18)	1.30	0.66–2.56
520–579	Digestive system diseases	37 (0.44)	17 (0.23)	1.36	0.76–2.43
580–629	Genitourinary system diseases	12 (0.14)	4 (0.06)	2.37	0.76–7.35
680–709	Skin diseases	10 (0.12)	3 (0.04)	2.21	0.60–8.15
710–739	Musculoskeletal system diseases	17 (0.20)	5 (0.07)	2.37	0.87–6.47
780–799	Symptoms, signs, ill-defined conditions	9 (0.11)	2 (0.03)	2.78	0.60–12.94
800–999	Injury and poisoning	18 (0.22)	4 (0.06)	2.84	0.95–8.50
Total number of diagnoses		215 (2.58)	70 (0.96)		

ICD-9-CM, International Classification of Diseases, 9th Revision, Clinical Modification; RR, risk ratio; CI, confidence interval.



**Figure 1** Frequency of post-war hospitalizations at KAMC among SANG soldiers stationed at Riyadh and at Al Khafji, 1989–1999



**Figure 2** (A) The adjusted cumulative probability of post-war hospitalization at KAMC among SANG soldiers stationed at Riyadh and at Al Khafji, January 1, 1991–December 31, 1999. (B) Expanded scale, y-axis

ICD-9-CM categories examined. When we compared the cumulative probability of all-cause hospitalization between the two study groups over time, we found a small, but statistically significant, difference at the end of our study period. Exposures or experiences related to war are a possible explanation for the increased risk of post-war hospitalizations in the Al Khafji group. However, the magnitude of the risk difference was very small, 0.004415, suggesting that if 1000 soldiers in each group were observed for 9 years, approximately four or five additional hospitalizations would occur in the Al Khafji group. Additionally, there were no unusual patterns or clusters in the ICD-9-CM categories to support a causal association.

Because the actual number of hospitalizations were so small, we recognize that point estimates are unstable, making it difficult to draw meaningful conclusions. However, the relative paucity of mental health admissions is intriguing, and it would be interesting to know if Saudi soldiers are less prone to psychiatric conditions or if some psychological diagnoses, such as post-traumatic stress disorder, are more strongly associated with Western cultures. These are challenging issues that deserve further systematic investigation.

We offer the following as possible explanations for our findings, perhaps the most salient being incomplete capture of hospitalization data. Data capture was dependent upon existing administrative databases, abstracted from paper as well as electronic records. Personnel records required translation from Arabic to English, and new procedures had to be established for data entry and coding, data linkages, and data quality control and validation. Unfortunately, we could not validate the completeness of data or fully account for missing data, and automated hospitalization data were not available for SANG family members or for soldiers who were discharged or resigned from SANG service.

Secular trends may have also affected the number of hospitalizations at KAMC. Just prior to the 1991 Gulf War, a substantial proportion of the local population left the Riyadh area and did not return until after the cessation of hostilities, thus reducing the demand for inpatient care at KAMC. During the war, KAMC was designated as a trauma centre for all coalition forces. As a result, all elective hospital admissions and health care for family members were directed elsewhere. The actual number of war-related hospitalizations was reported to be very low (only 22 patients with ICD-9-CM codes relating specifically to war trauma, E990-E999). Hospital admissions gradually returned to pre-war levels by 1993. However, alterations in the health care delivery system or variations in patterns of utilization may have lingered during the transition period. Finally, the battle of Al Khafji took place just after a new contingent of SANG officers (about 300) completed their training and were immediately assigned to the Al Khafji region. A greater than expected rate of resignation from this new group of officers may have contributed to fewer overall hospitalizations since automated health data are not available for those who resign or are discharged from SANG service.

It is interesting to note that soldiers from Al Khafji were consistently hospitalized in greater numbers from 1991 to 1999 across all major ICD-9-CM categories and all diagnoses, even though none of the adjusted relative risks for these categories achieved statistical significance. In comparing the demographic and military service characteristics of SANG soldiers located at Al Khafji and Riyadh, age and length of service were similarly distributed in the two groups. SANG soldiers typically serve their entire career in the Saudi National Guard, and this is consistent with the high proportion observed to remain on active duty following the Gulf War. As expected, older soldiers were more likely to be hospitalized, as well as those who served  $\geq 9$  years in the military. Our findings do not support an association between adverse or unusual health outcomes and environmental or war-related exposures.

Since no tertiary care facility existed near Al Khafji during our study period, all Al Khafji soldiers with health conditions requiring hospital admission were referred to KAMC in Riyadh.

On the other hand, alternate health care services were available to the soldiers in the Riyadh area, a more urban and populous region. This may explain, in part, the consistently larger number of hospitalizations across all major diagnostic categories in the Al Khafji group. Another possible explanation may relate to the larger proportion of soldiers stationed at Riyadh who resigned or were discharged from SANG, making them ineligible for care at KAMC.

Finally, our finding of a difference in the hospitalization experience of the Al Khafji and Riyadh soldiers leads us to speculate that the two groups may, in fact, represent two distinct subpopulations within the SANG and that the groups may have had divergent geopolitical, economic, and/or sociobehavioural characteristics that may have affected post-war utilization of health care services at KAMC. We acknowledge that our study findings cannot be generalized to the population of SANG soldiers as a whole, nor to Saudi Arabian military forces other than SANG.

### **Study limitations**

Outpatient data, pharmacy data, cancer registry data, mortality data, and self-reported symptoms data were either not in an automated format or not available for our study period. As a result, we could not examine the full spectrum of possible post-war health effects within our study groups. However, automated hospitalization data were available and permitted our preliminary epidemiological study. Although the use of hospitalization data has inherent limitations, it is an objective measure that implies morbidity severe enough for individuals to be admitted for inpatient care and has been assessed in other Gulf War veteran populations.<sup>33,36,38,39,54</sup>

We recognize that other factors may make understanding and interpreting any observed association between Gulf War service and health outcomes among SANG soldiers challenging, including sociocultural norms and health care utilization patterns unique to this population.

### **Study strengths**

Despite a number of challenges, this was the first systematic epidemiological investigation of the post-war hospitalization experience of a coalition partner from the Gulf region. We were able to characterize various existing health data sources and evaluate their suitability for monitoring the health status of the SANG population. Additionally, professional collaborative relationships were established among Saudi investigators in Riyadh and US investigators representing the Department of Defense and the Department of Health and Human Services, which, we are convinced, will ultimately add to our understanding of the possible health effects of deployment.

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### **Disclaimer**

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This research has been conducted in compliance with all applicable federal regulations governing the protection of human subjects in research.

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## Commentary: Adding to our comprehension of Gulf War health questions

Kenneth Craig Hyams

The findings of the study published in this edition of the Journal by Gackstetter *et al.*, provides a valuable addition to our understanding of the health questions that arose after the 1991 Gulf War.<sup>1</sup> Nearly all medical research on these questions has been conducted on the 750 000 troops deployed from the United States, the United Kingdom, Canada, and Australia, with little research conducted among local populations of the Arabian Gulf region.<sup>2</sup> However, the inhabitants of this region are an ideal group for study because they endured health threats similar to those of the Western military personnel and often for much longer periods of time.

The study by Gackstetter and colleagues evaluated the hospital experience of Saudi Arabian National Guard soldiers during the 9 year period between the end of the war in 1991 and 1999. Two groups were compared: 8342 soldiers exposed to combat on the Kuwait–Saudi Arabia border and 7270 soldiers stationed 300 miles south of the actual fighting in the Saudi Arabian Capitol of Riyadh. A small increase in risk of hospitalization was found among combat-exposed troops (risk ratio = 1.8) but no unusual patterns of illnesses were observed. These results suggest that the health of troops native to the Gulf region was not severely affected by any particular disease due to service in the war zone.

The findings of this study are consistent with studies conducted on Western military personnel. Multiple studies have consistently shown that Gulf War veterans in the United States,<sup>3</sup> the United Kingdom,<sup>4</sup> Canada,<sup>5</sup> and Australia<sup>6</sup> report more symptoms and health problems than similar groups of military personnel. However, the hospitalization experience of Gulf War veterans has not been unusual,<sup>7</sup> and clinical studies of over 100 000 Gulf war veterans have not identified a singular cause for reported health problems.<sup>8</sup>

Some studies have shown a possible neurological basis for difficult-to-explain symptoms among Gulf War veterans—the postulated ‘Gulf War syndrome’.<sup>9</sup> Neurological abnormalities have

been attributed to exposure to organophosphate pesticides and chemical warfare agents and to the drug pyridostigmine bromide, which was used among some Coalition troops as a pre-treatment against exposure to chemical warfare agents.<sup>10</sup> In response to these studies, the Secretary of the United States Department of Veterans Affairs (VA) has recently committed 15 million dollars to new Gulf War research funding to continue the study of health problems of Gulf War veterans. These funds are in addition to the estimated 242 million dollars that has been spent since 1991 on Gulf War related research in the United States.<sup>2</sup>

Besides exposure to organophosphate chemicals, other exposures have been indicated as possible causes of health problems among Gulf War veterans, including oil well fire smoke, multiple vaccinations, endemic infectious diseases like leishmaniasis, and depleted uranium (DU) contained in munitions used by Coalition forces. None of these possible health threats has been demonstrated to have caused widespread health problems among veterans of the 1991 Gulf War.<sup>11</sup>

There have been numerous media reports that have attributed cancer and birth defects in southern Iraq to exposure to DU munitions used against Iraqi troops during the war. No systematic investigation has been conducted to confirm this potential health risk. However, several studies have concluded that DU was not a health risk for Gulf War troops unless a veteran was actually wounded by DU shrapnel; DU was mainly expended in unpopulated desert regions and not in urban areas, and DU was not a health threat in the Balkans where it was also utilized.<sup>12</sup>

It is noteworthy that adverse health effects have not been identified in all studies of Gulf War veterans. The mortality experience of the 697 000 US troops deployed in the Gulf has been nearly equivalent to non-deployed military personnel for the first 10 years after the war.<sup>13</sup> Compared with demographically similar civilian populations, the mortality rate of US Gulf War veterans has actually been favourable, less than one-half that of non-military controls. The mortality experience of Gulf War veterans from the United Kingdom has also been favourable compared with the civilian population.

Progress in the understanding of the health problems of Gulf War veterans has been agonizingly slow over the last 14 years.

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### 14. ABSTRACT (maximum 200 words)

There has been considerable publicity that the 1991 Gulf War may have caused a wide array of health problems in military personnel. Although postwar health outcomes have been studied in US, British, Canadian, and other deployed troops, this issue has not been previously evaluated in coalition forces native to the Gulf region.

A collaborative team of US and Saudi health researchers was assembled, data sources evaluated, and hospitalizations among Saudi Arabian National Guard (SANG) soldiers between 1991 and 1999 analyzed. Multivariate modeling was used to evaluate differences between 8342 soldiers exposed to combat at Al Khafji and a comparison group of 7270 soldiers in the Riyadh area.

This is the first reported epidemiological investigation of postwar hospitalization among coalition forces native to the Gulf region that participated in the 1991 Gulf War. A very small increase in hospitalizations was identified in SANG soldiers exposed to combat at Al Khafji. However, because of data limitations, the clinical relevance of this finding should be interpreted with caution. Future collaborative studies to better understand the health effects of deployment should be encouraged.

### 15. SUBJECT TERMS

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